NOTES ON
BRITISH REFUSE DESTRUCTORS

WITH AN

INTRODUCTORY COMPARISON OF
BRITISH REFUSE DESTRUCTORS
AND
AMERICAN GARBAGE FURNACES

BY

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BRITISH REFUSE DESTRUCTORS AND AMERICAN GARBAGE FURNACES.

In no other branch of the municipal service has Great Britain so far outstripped the United States as in refuse cremation. In all things pertaining to water supply, sewerage, paving, street lighting and cleaning our best practice is at least as good as is theirs: Where we fail it is because we do not live up to our knowledge. But in the disposal of garbage and other refuse by cremation our most notable attainments, if conditions in the two countries warrant comparison, are not on a par with the most ordinary and common practice in England, Scotland and Wales.

The British householder throws his garbage, ashes and miscellaneous refuse into a common "dust bin" or other receptacle, from which the mixture is taken to a destructor equipped with forced blast, steam boilers, economizers, superheaters and all known modern devices for producing complete combustion and high temperatures and for utilizing every possible heat unit before the flue gases reach the chimney. The residue from the mixed refuse is a highly vitrified clinker and a very small amount of fine ash and flue dust. The clinker is crushed and used for sewage filters, road foundations, concrete or, in the finer sizes, and sometimes combined with fine ash, for builder's mortar. The steam generated in the destructor boilers is supplied to electric light and power stations or is used to pump sewage or water; and whatever else is done or not done with it the steam is invariably used for "works purposes," such as driving clinker crushers and mortar mills. The steam is also used to produce forced blast, either directly through steam jets or indirectly by driving fans for air blast.

Mixed refuse is found throughtout Great Britain whether destructors are used or not. Where destructors are not used the refuse is "tipped" on land or carried to sea, reduction, or the recovery of grease and fertilizing material from kitchen garbage, being unknown in England and Scotland.

In the United States most of the larger cities which dispose of their refuse by any means but dumping on land or in water, contract with private companies for treating the garbage in reduction works. The alternative is cremation, which at one time or another has been practiced in a hundred cities and towns.

Wherever in this country either furnaces or reduction works are employed, with one or two possible exceptions in the case of furnaces, the ashes are excluded from the garbage and are got rid of separately.

In the United States fuel is practically always bought and used to burn garbage; in Great Britain it appears that purchased fuel was rarely used to aid in the combustion of the mixed refuse in the early destructors, and is never used in the modern installations. Many an American garbage furnace has been shut down for months at a time or finally abandoned because of the alleged excessive cost of fuel. British destructors have practically always supplied enough heat from the self-burned refuse to meet all the demands for works purposes and to-day they are supplying many hundreds of horsepower for generating electricity and for pumping sewage and water.

Whence these radical differences? Americans are not backward in developing furnaces and boilers for raising steam from coal, oil and natural gas, and they are credited abroad as well as at home with carrying to a high degree the utilization of many kinds of wastes. Why then do they buy coal to burn municipal wastes instead of using those wastes to save coal? Or dropping for

the moment all thought of utilizing or saving anything, why have so many American garbage furnaces failed sanitarily or at best given poor results?

Various reasons have been given for the poor sanitary and economic results shown by American furnaces. In attempting to find a fundamental reason perhaps the most common assumption has been that we fail because we have more garbage per capita, and wetter garbage, too, than do British municipalities, notwithstanding which we throw away vast quantities of unburned coal in our ashes which might be utilized to burn our garbage. It is held by good engineers on both sides of the Atlantic that if we mixed our garbage, ashes and other combustible refuse the resultant would have as high a calorific value and be as easily burned as is the British refuse. Unfortunately readily comparable figures of the composition of American and British refuse are meager; too meager, we fear, to be a safe basis for definite conclusions of general application. Undoubtedly there are large quantities of unburned coal in the ashes of American cities, but it must be remembered that throughout a large part of the country the low winter temperatures make necessary the burning of large quantities of coal, mostly in closed stoves and furnaces, the best of which leave relatively small proportions of unburned coal. The result is a far larger volume of ashes per capita than in England, where open fireplaces are the rule, and where house temperatures are in the vicinity of 60° F., instead of our 70° F.

Assuming that our ashes contain large amounts of coal, we must consider the cost of hauling such large volumes to garbage furnaces compared with the cost of laying down coal by rail or water. We must remember also that many of the British cities are built on relatively small areas, and that British refuse destructors are often centrally located, whereas many American cities are sprawled

over large areas, and so great is the prejudice here against any kind of garbage disposal works that our furnaces are forced into the outskirts, requiring long hauls to reach them, the last portion of which is likely to be over poor roads. Relatively short hauls suffice for our ashes, so long as they are unmixed with garbage. As a matter of fact, however, our smaller cities make no attempt to collect ashes. In such cases ash collection and haulage, if done for the sake of the fuel value of the ashes, would be a heavy debit charge against the furnace.

In winter our northern cities would have an enormous volume of ashes and but little garbage, little both as compared with the ashes and with the summer garbage. In summer the proportions would be reversed. In fact, where gas ranges are widely used, as they are coming to be in most cities during the summer months, there are few ashes in summer and large quantities of garbage; large because no wastes can be burned in gas ranges and because of our heavy consumption of green stuff in the summer, some of which, like green corn and watermelons, is practically unknown in Great Britain.

There is no question in our minds but that mixed refuse has contributed very materially to the development of the British refuse destructor, with its high temperatures and its utilization of heat from wastes alone. While we doubt the possibility of developing just such destructors here without mixing ashes with garbage, we also feel that more American data are needed before it can be safely concluded that mixed American refuse can be made to burn itself the year around, say nothing of producing power for electrical or other purposes. There is this to be said, however: Neither mixed refuse or garbage can be satisfactorily burned without high temperatures, and once produced why should so much heat be allowed to go up the chimney unutilized?

It is a pity that some American city does not learn just what the self-burning and steam-raising power of its various classes of refuse is. In New York and Boston the unsalable portions of the third separation ((1) garbage, (2) ashes, and (3) the other classes of refuse, including paper and rags) have been burned for a number of years, and a little heat has been utilized, but the full value of tailings from these sorting plants has never been determined. The refuse-burning plant now proposed in connection with the electric lighting of the Williamsburgh Bridge, as we understand it, will not receive either ashes or garbage.

Whatever might be the advantage of mixed refuse in America, it is certain that its mere substitution for the garbage now burned at so much expense and with too frequent nuisance in American furnaces would not in and of itself raise our furnaces to the high class long occupied by British refuse destructors. Some change in the design of American furnaces is imperative.

Taken as a whole, perhaps the greatest fault in the design of our garbage furnaces has been an arrangement of large grates and feed holes that has resulted in dumping whole wagon loads of coal and very wet green garbage directly onto the fire. Another notable fault has been the lack of division of the garbage grates, on account of which the opening of one stoking door checks the fire in the whole plant. In an attempt to offset these faults, many of the furnaces have been provided with secondary grates on which coal is burned, the gases of combustion passing over the garbage. In strong contrast with these features the typical British destructor has, until recently, been made up of relatively small units or cells, with small grates, back of which are drying hearths which receive the fresh charges of refuse and give it an opportunity to dry and to acquire some heat. The dried and often hot refuse is raked forward as desired onto the single fire pro-

vided for each cell, combustion being greatly stimulated by the forced blast already mentioned.

It is not yet generally known in America that a type of British refuse destructors has come to the front within the last few years which resembles the typical American garbage furnace to the extent of having one large grate, but it is important to note that the ashpit space beneath these grates is most carefully divided, with the idea that, in connection with the forced draft, there shall be, in point of cooling the fire during charging or clinkering, a series of small grates, while at the same time giving the benefit of one large fire. There is no drying hearth in some of these furnaces, but neither is there a heavy top feed to dull the fire, as in the American furnaces. Instead, the refuse is hand fed, and is spread with care over the grate so as to check the fire as little as possible.

Charging or feeding, and also stoking, bring to mind the lamentable fact that even could we be assured that our refuse was as easily handled as the British, and even if we had furnaces in all respects as well designed and built as theirs, we should still lack the experienced foremen or managers of the furnaces and the skilled chargers and stokers common abroad. Of what avail to provide the best of furnaces if they are to be turned over to political spoilsmen to operate? But politics and corruption aside, and with the best of intentions as to engaging and retaining men on account of merit alone, how are competent men to be found in a country where none have even been trained to the work? A manufacturer of British refuse destructors has stated that if he were to come here he would try to engage gas works stokers as workmen at his destructor installations, but with the rapid change from coal gas to water gas good gas stokers are becoming more and more scarce in this country.

Inexperienced labor and the likelihood of losing laborers by a political upheaval as soon as partly

trained are serious obstacles in the development of garbage furnaces or refuse destructors suited to American needs; obstacles, too, that make one hesitate about increasing the bulk of refuse by adding ashes to the garbage.

Nevertheless, we must face the problem, regardless of labor conditions, and try to improve on the design of our furnaces, or soon we shall have nothing but reduction plants, outside of the large and medium-sized cities.

The foregoing remark suggests that while British municipalities and private enterprise have been perfecting refuse destructors, American cities have taken no direct part in the improvement of either furnaces or reduction plants, while most of the private capital and engineering knowledge put into garbage disposal has been swallowed up by reduction systems; and in the latter little of the best engineering or chemical talent of the country has yet gone. Why? Partly because our garbage reduction systems have been so largely mere outgrowths of more or less extensive fat and bone rendering establishments, partly because of the short terms of garbage disposal contracts, which would rarely warrant such outlays as are even now made were it not for powerful political alliances which are believed to ensure renewal without competition, partly because of the bonus from the city, which, again through political influence, is often sufficient to check ambition for improvements in plants which may after all have to be abandoned on account of political reverses, and in general because the reduction companies have had little effective competition among themselves and practically none from the furnaces, and have never had their financial and engineering operations under adequate municipal control.

The conditions affecting the development of American garbage furnaces have been still less favorable than those governing reduction sys-

tems. Practically all the furnaces have been built to sell to municipalities, and rarely has there been any adequate engineering supervision by the city or any acceptance test worthy the name. The furnace companies, as a rule, have been too weak to bid with any assurance against reduction companies desiring large contracts, so there has been no stimulus of competition here. Rarely, indeed, has an engineer of any note been engaged by any of the American garbage furnace companies, and such companies as have employed engineers of relatively marked ability have almost invariably held their engineers so severely in check as to dwarf their plans for advance.

It is not a pleasing task to point out these deficiencies in one branch of American municipal engineering and sanitation. It is all the less pleasant, though perhaps somewhat easier, because the author has written so often on the unsatisfactory condition of garboge disposal in America. He has never before, however, drawn so many contrasts between American and British conditions. These contrasts have been forced upon him by the recent publication of two notable British books by Mr. W. F. Goodrich, Assoc. Inst. M. E., entitled "The Economic Disposal of Town's Refuse" (1901), and "Refuse Disposal and Power Production" (1094); and also by his visit to the refuse destructors here described. To a slight extent, only, were the destructors visited selected because of their merit. Instead, they were taken as opportunity afforded during a tour of inspection for other purposes. And yet it may be seen from the notes how far different is the current practice in refuse burning abroad and at home. It may well be that not all the foreign conditions are comparable with our own, but certainly they are suggestive. Above all they suggest the necessity of treating garbage and refuse disposal here as it is treated abroad, namely, as an engineering problem.

NOTES ON BRITISH REFUSE DESTRUCTORS.

Destructors in Four London Boroughs.

The Metropolitan County of London is composed of the cities of London and Westminster and 27 boroughs in addition. About half of these municipalities have refuse destructors and of these four were visited by the writer.

THE COMBINED REFUSE DESTRUCTOR AND ELECTRIC LIGHTING PLANT AT SHOREDITCH.

Exaggerated claims for the production of electricity from municipal refuse were made when the combined refuse destructor and electric lighting plant was opened at Shoreditch in 1897. It was asserted that thenceforth the refuse of a city would afford ample power to light it by electricity, thus greatly relieving the sanitary and lighting departments and the overburdened taxpayers. Some basis, at least, for these assertions was afforded by remarks made at the time by Lord Kelvin. The enthusiasm over this alleged wonderful advance in municipal sanitation and economy reached the United States and was spread by the editors of the daily press, quite regardless of the differences in British and American conditions. A few figures presented in Engineering News for Aug. 26, 1897, were sufficient to show some of the limitations of such combined installations in America. A half dozen years have elapsed and the cities of the United States have done practically nothing towards the production of power from refuse. In Great Britain and portions of Continental Europe, however, the majority of the refuse destructors are developing steam for works purposes and in addition most of the destructors built during the last few years are com-

bined with electric light or railway stations, sewage or water-works. Nevertheless, the word has gone out that the Shoreditch combined works are a failure. To a degree this report seems to be true, but if so, it is largely because the works were too ambitious in scope and because too much was claimed for them by their promoters before the works had been given the test of some months or years of operation. Such, at least, I found to be the opinion of some of the men in England most competent to pass judgment on the Shoreditch plant.

Before describing the works or giving any further opinions regarding them, I wish to state that I saw the destructor under conditions unfavorable for obtaining exact information. Mr. J. Rush Dixon, Assoc. M. Inst. C. E., Borough Surveyor, was unable to see me at all; Mr. O. B. Richardson, Manager of the destructor, was not to be found; and the man who conducted me over the works said he was unable to give me some of the detailed information which I desired.*

Shoreditch is a central London borough having a population of 118,705 on an area of only 640 acres, of which only 6½ acres is composed of open spaces. The refuse destructors comprise twelve Fryer's improved top-fed cells, with Boulnois, Wood & Brodie's charging apparatus built by Manlove, Alliott & Co., of Nottingham, and put in operation in June, 1897. Kincaid, Waller & Manville, of Westminster, were employed as engineers for the combined refuse destructor and electric

*The lack of information due to the cause just named has been partly made up since by the paper sent by Mr. H. Newton Russell, M. Inst. M. E., Borough Electrical Engineer of Shoreditch, to the joint meeting of the British Institution of Mechanical Engineers and the American Society of Mechanical Engineers at Chicago in May and June, 1904 (Vol. XXV., Trans. Am. Soc. M. E.). The paper was entitled "Refuse Destruction by Burning, and the Utilization of Heat Generated." The paper was devoted chiefly to a description of the Shoreditch destructor and has been used to supplement my notes taken at Shoreditch.

works. The rated capacity of the plant is 100 long tons a day. The average amount burned is about 85 long tons a day, running as low as 60 tons in summer and as high as 140 tons in winter. The cells are arranged six back to back on either side of the main flue and between each parallel pair of cells is a Babcock & Wilcox boiler, making a total of six boilers. Each boiler has a heating surface of 1,300 sq. ft., and a grate surface, for independent firing, of 27 sq. ft. From the dilapidated appearance of this apparatus I thought it was not in use, but the man who showed me about said that it was in service. This apparatus attracted so much attention when it was installed that I will quote, with slight abbreviation, what Mr. Russell says about it and closely allied subjects in his recent paper (mentined in the footnote herewith).

A somewhat novel system of storing hot feed-water is in use (sometimes called thermal storage). The reason that led to its adoption was that, at the inception of the combined scheme, it was not thought that for some time at least the demand for electric current would be very great, and that during the hours of daylight, when refuse was of necessity being burned, it was feared that some of the heat would be lost, owing to the small demand for steam.

It was therefore decided to instal Halpin's Thermal Storage system, with a view of storing up heat in the form of water at a high temperature. The storage vessel was originally connected to the main line of steam pipes, with a view to it being gradually filled by pumping in cold feed-water, which would be heated by means of spare heat generated in the refuse furnaces during the daytime. The intention was that a portion of the steam raised in the boilers of the destructor plant would be used as required for the engine driving the electric generators, and the balance passed over to the thermal storage vessel, where it would part with its heat to the feed-water. The engines were designed to have adjustable cut-offs, so as to drive their full load with pressure varying from 200 lbs. to 120 lbs. per sq. in. The object aimed at was to fill up the thermal storage vessel at times of low load with water at a temperature corresponding to a

pressure of 200 lbs. per sq. in., and at the time of greatest demand for current. not only feed the boiler from the storage tank, but by the evaporation of the hot water as the pressure fell steam would be given off to augment that supplied by the ordinary boilers. The process would proceed until the pressure reached the lowest point, i. e., 120 lbs., by which time it was thought that the time of maximum demand would have passed, and that the ordinary boilers would be able to cope with the load. In practice things worked out very differently. First it was found that pumping cold water into the vessel into which high-pressure steam was being admitted caused such a water hammering that the practice had to be discontinued forthwith, and it was found necessary to partially heat the feed-water by passing it through a Green's economizer before putting it into the thermal storage vessel; this, however, effectively got over the difficulty. Secondly, by the autumn of 1897 the demand for steam during the daytime had reached nearly the limit of heat it was possible to get from the refuse furnaces; so, having nothing to spare from that source, no additional thermal storage vessels were necessary.

The boiler-feed is now furnished by a Weir pump, which forces the cold water through a Green's economizer, where it is heated to a temperature varying with the load, although at light loads a maximum temperature of 250° F. has been reached. The feed then passes into the thermal storage vessel, fixed at a level of about 20 ft. above the boilers. This vessel is simply a cylindrical shell, 30 x 8 ft., which is used for storing, during the hours of light load, hot water with which the boilers are fed directly by gravity.

Most of the lime in the feed-water comes down in the feed-storage vessel; the amount taken out of the vessel after a run of seven months was little short of one ton after being dried.. The deposit in the economizer tubes was less than 1-16-in. in thickness; it was of a harder nature than that in the feed-storage vessel, and could be removed by a scraper. The boiler tubes were frequently examined and were found fairly clean, the deposit in the tubes amounting to an average of 3-32-in.

This system of feed-storage has undoubtedly contributed considerably to the success of the plant generally; it enables the engineer in charge of the steam-raising plant to store hot feed-water during about 18 hours out of the 24,

so that at the time of maximum load the vessel is about two-thirds full of feed-water at a pressure and temperature equal to that of the boilers.* Tests have been made on several occasions, when the demand for electricity has been within the range of the refuse furnace to supply the necessary heat, and when, of course, no coal was used. The result showed 0.95 lb. of water evaporated at a steam pressure averaging 180 lbs. for 1 lb. of refuse burned. A considerable reduction must, however, be made in these figures when taken over say twelve months. Damp weather (which affects the quality of the refuse), low barometric pressure, choked flues, warped doors, the starting up of furnaces, etc., may easily bring down the average results over a lengthy period to 0.5 lb. of water for 1 lb. of refuse burned. The existing vessel has, however, proved most serviceable for the storage of hot feed-water, and as a means of removing the impurities from the feed-water before it reaches the boiler. The economizer was not erected until some time after the works were opened, as it was not anticipated that the temperature of flue-gases would warrant its insertion. However, after the plant had been running steadily for some time, and careful tests had been taken, it was found that the flue-gases at the base of the chimney had a maximum temperature of 700° F.

The chimney is of brick and is 150 ft. high. Both Sturtevant fans and steam jets are available for maintaining a forced draft. Mr. Russell prefers the fans. There are three of these, designed to give 8,000 cu. ft. of air per minute. They are driven by an electric motor. All three of the fans are not required except during the heaviest loads. The air for the fans is drawn from the top platform, in order to take advantage of the greater heat of the air at that place.

The refuse is collected by the borough in four-wheeled wagons and, the site of the works being so restricted and land there so valuable that an inclined driveway was considered impracticable, the refuse is dumped at the ground level into tip

*For full details of Thermal Storage System as applied to ordinary steam raising plants, see Paper on "Economy of Fuel in Electric Generating Stations," by H. McLaren, M. Inst. M. E., Proc. Inst. M. E., July 29, 1903.

cars each holding one wagon load. The cars are raised on electric lifts or elevators, run forward on a trolley track and dumped into charging cars or else into a storage bin. The charging cars are run over the destructor feed holes and emptied by means of flat slides in the bottoms of the cars. These cars are also moved by electricity. On the basis of 25,000 long tons of refuse burned per year an average of 0.52 KW. hour of electric energy is required to operate the lifts or elevators and trucks.

The clinker is dumped in a paved yard and quenched with water. It gave evidence of good burning. Most of the clinker was not being utilized at the time of my visit, but some was being used for road making.

My visit was at about 3 p. m., on Thursday, March 17, 1904. I saw very little garbage proper, but was told that there was more the first day of each week. All the refuse was dry.

The dust in the destructor building was thick, both in the air and wherever it could find lodgement. In fact, it was annoying. No odor was observed and the chimney top was free from smoke.

The cost of the destructor, exclusive of site, is given by Mr. Russell in his paper, already mentioned, as about £15,000, or some $75,000. This includes two-thirds of the cost of the chimney, the other third being charged to the electricity works. The total cost of the chimney was £2,790, or about $13,550. In Goodrich's "Refuse Disposal and Power Production" (London, 1904), the cost of the destructor, also exclusive of site, is given as £20,527, or about $100,000. The 13,450 sq. ft. of land comprising the destructor site cost 13 shillings or about $3.25 per sq. ft., or a total of $42,360.

As to the cost of operation, Mr. Russell, in his paper, says:

The amount of refuse destroyed is between 25,000 and

26,000 long tons per annum. The residue (or clinker) amounts to from 33 to 35% of the weight. The cost for labor for burning the refuse is very high, compared with that at other destructor plants, and is one of the most serious factors for consideration. The nearer a destructor is to the center of a large city, the greater will be the wage bill, and this fact must be borne in mind in considering any new scheme:

	Per long ton.		
	s.	d.	cts.
Cost for handling and burning refuse, including yard men, average	2	6	61
Clerks and establishment of charges	0	4½	9
Repairs and maintenance of cells and plant and cost of engineering stores	0	10	20
Total	3	8½	90

The average number of men employed in actually handling the refuse (per shift of 8 hours):

Furnace men	4	
Top men	3	
Lift men	1	daytime only.
Yard men (laborers)	2	daytime only.
Foreman in charge of shift	1	

The above figures are for the fifth year's working, when considerable repairs were necessary to the furnace, linings, doors, etc.

The works are run on the eight-hour-shift system, seven days per week.

The amount of electric energy consumed in the burning and handling of 25,000 long tons of refuse is as follows:

	Units per tons.
Electric fans	4.0
Electric lifts and trucks	0.5
Electric lighting	0.48
Total	4.98

The operating expenses, as given above, do not include the disposal of clinker. At some destructors clinker is considered as a source of revenue, but it is doubtful whether proper debit charges are, as a rule, made against it. Mr. Russell states in his paper that where destructors are located in the center of large cities clinker disposal

is a difficult and expensive matter—it is usually found impracticable to use more than a small portion for slab and mortar making. The greater portion has to be re-

moved in vans to the outskirts of the city. This in the case of Shoreditch costs 2s. or 50 cts. per ton of clinker, and should be taken into account in the total cost for disposal. When building operations, road-making, etc., are going on extensively in the neighborhood the clinker from refuse destructors is of considerable value. When properly treated it may be made into most excellent paving slabs, bricks, concrete and mortar.

At Shoreditch the clinker amounts to from 33 to 35% of the original refuse. Therefore when it has to be got rid of by carting away its disposal adds about 17 cts. per ton to the cost of the destructor operation. This brings the total cost of operating the destructor up to $1.07 per long ton. The exact amount to allow for capital expenses is uncertain, owing to the differences in capital outlay as given by Mr. Russell and by Mr. Goodrich. But taking Mr. Russell's figures (which are the lowest), we have, say a capital outlay of $115,000, which at only 7% for capital charges would amount to about $8,000 or some 30 cts. per long ton on 25,000 long tons per year. This would bring the total cost of refuse destruction up to $1.37, or with a slight allowance for contingencies, to $1.50 per long ton.

As an offset to this, there is the value of the steam delivered to the electricity works and to other municipal buildings adjoining the destructor; but unfortunately Mr. Russell neither states what this amounts to nor gives figures from which a computation can be made. He does say that the exhaust steam from the non-condensing engines in the electric generating station "is put through heaters which supply all the hot water necessary" for the public baths and wash house; that the public library is heated by exhaust steam from the feed pumps; and that live steam from the boilers is supplied for boiling clothes in the wash house. For the live steam a yearly rental of nearly £250, or about $1,200, is charged, but whether this steam is from the destructor boilers or from the supplementary boilers is not stated. Nor is there anything to indicate

what percentage of the steam used by the engines in the generating station is from the destructor boilers and what from the supplementary boilers. It is interesting to note that the public baths and wash house include one swimming pool, 100 x 40 ft. and another 75 x 34 ft., 76 bath tubs and 50 troughs for washing clothes.

A brick wall separates the electricity works from the destructor building. The total capacity of the electric station is about 2,500 KW. Independent coal-fired boilers, as already intimated, supply the steam needed beyond the yield of the destructor boilers, which is, of course, considerable.

THE TOOTING OR WANDSWORTH DESTRUCTOR.

The destructor at Tooting, in the London borough of Wandsworth, is provided with direct charging apparatus.

Wandsworth has a population of about 230,000, and the large area of 14½ square miles, of which nearly two square miles are in commons or other open spaces. The refuse destructor serves only two or three districts of the borough, the balance of the refuse being either carted or barged away. Mr. H. J. Marten is surveyor for the portion of the borough in which the destructor is located, and was the inventor of the charging apparatus. Mr. George Cowell is manager of the destructor, and showed me around the plant.

The destructor was erected in 1899, by Meldrum Bros., of Manchester. It consists of four Beaman & Deas top-fed cells, with the direct charging apparatus already mentioned. Each cell has an effective grate area of 25 sq. ft. The chimney is 150 ft. high and a fan is used for forced draft. A Babcock & Wilcox boiler with a heating surface of 1,619 sq. ft. supplies steam for works purposes, including electric lights for the works and

for three or four adjacent streets. The cells are arranged in two pairs and have a combined rated daily capacity of 70 long tons. The building is of brick, with a steel and slate roof. There is an inclined stone-paved ramp, the tipping floor is large and well paved and the clinkering floor is also paved. Water-closets and baths are provided for the men, and I was told that the baths are used daily. There is also a mess-room for the men, and there are good stables, with paved floors, for the horses.

The borough collects its refuse in four-wheeled tipping wagons and all refuse brought to the destructor is weighed. Extra vans are provided for most of the storage required, but there are some small storage pockets alongside the charging hoppers into which the vans can be tipped. The tipping floor is spacious enough to store a number of refuse wagons. An extra horse is provided for moving the stored wagons.

The charging apparatus consists of a wrought-iron hopper, with a sliding bottom 2 ft. wide and 5 ft. long. When a wagon load is to be fed into the destructor the bottom of the hopper is slid to one side by means of a hand-wheel and lever, operated from the tipping floor. The wagon is then backed up against the tipping beam, the wheels moving in grooves designed to bring the wagon to the same position each time, thus ensuring that the refuse will be tipped directly through the hopper onto the charging grate. After tipping the seal to the hopper is closed. The charge is pushed onto the fire, as desired, from the rear, enabling the operator to keep cooler than if he were compelled to rake the charge over the fire from the front.

The cells are fed and clinkered about once in two hours. The clinker is raked into barrows, wheeled out and dumped in an unpaved yard. Water is used to cool the clinker sufficiently to enable the men to get about comfortably. The

clinker is used to grade streets ready for macadam and the finer portions are screened out and utilized for unpaved footpaths and as a base for sidewalk flagstones. In addition, some clinker is sold to contractors, who call for it and pay two shillings, or 48.6 cts., per load of about 1½ cu. yds., or approximately 2,000 lbs. The fine ash from below the grate is sold under like conditions at two shillings per load of 1½ cu. yds., or about 1,570 lbs. The same price is obtained for like volumes of flue dust, weighing about 1,350 lbs.

The large tins (or cans) are picked out before the refuse is burned. Formerly, the borough flattened all the tins with a steam roller in the destructor yard and placed them beneath the clinker in road-making. At the time of my visit a contractor was being paid 2½ shillings per long ton for removing the tins, which he sorts and sells. The borough has had an offer for crushed or flattened tins of 12½ shillings, or $3.04, per long ton at the destructor yard, or $4.87 delivered at a dock, but the margin between the price offered and the labor cost was considered too small. A contractor, Mr. Cowell said, could make a profit at the figures named, since besides paying his men lower wages, he would "hustle them about a little bit more than we would here."

The destructors are run from 6 p. m. Sunday to 6 a. m. Saturday, during which time they burn about 435 long tons of refuse. The flues are cleaned on Saturdays. One of the four cells is shut down at night. The men work in 12-hour shifts, four firemen in the day and three at night. Only one top man is employed during each shift. These nine men are paid 6½ d., or about 13 cts. per hour. The manager starts the dynamo at night and the top man looks after it. A boy is stationed at the scales and office.

Omitting the boy and the manager, allowing nothing for cleaning up on Saturday, and assuming an average of 435 long tons of refuse burned

per week, we have the following as the labor cost per ton:

$$\frac{9 \text{ (men)} \times 66 \text{ (hours)} \times 6\frac{1}{2} \text{ (d.)}}{435 \text{ (long tons)}} = 8\frac{3}{4} \text{ d.} = 17\frac{1}{2} \text{ cts.}$$

The installation, not including the inclined roadway, cost £5,005, or about $24,325.

For lighting purposes outside the building, when the fires are not going, electric storage batteries are provided. A little coal is used Sunday nights, to get up steam to drive the fan for the forced draft.

I visited this destructor about noon of Wednesday, March 23, 1904. I saw scarcely any green stuff in the refuse. I was told that there was comparatively little garbage in winter and little else during the summer. The plant in general was in a clean condition. There were no odors. Only a small amount of light smoke was visible at the chimney top.

A continuous 120-hour test of two cells of this destructor was made on Feb. 2 to 7 (year not given). This test is reported in detail in Goodrich's "Refuse Disposal and Power Production," where it is stated that it was made under ordinary working conditions, mainly to determine the power-producing value of the refuse. With 50 sq. ft. of grate surface and 1,619 sq. ft. of boiler heating surface there were put through the two cells a total of 411,264 lbs. of refuse, including 728 lbs. of tins. Deducting the tins the average amount of refuse burned per hour was 3,421 lbs. for the two cells, or 68.4 lbs. per sq. ft. of grate surface, and 2.1 lbs. per sq. ft. of boiler heating surface per hour. The residuals were 38.2% of the refuse by weight, of which 37% was clinker, 0.4% ashes from beneath the grates, and 0.8% flue dust. The total amount of water evaporated was 419,833 lbs., which was 1.02 lbs. of water to 1 lb. of refuse burned. On the basis of a temperature of 212° F. the evaporation was at the average

rate of 1.24 lbs. of water per 1 lb. of refuse and 2.6 lbs. per sq. ft. of boiler heating surface. Some of the average temperatures were as follows: At the boiler inlet, 1,698° F.; boiler outlet, 637; chimney base, 629; feed water, 46° F.

THE WESTMINSTER DESTRUCTOR.

Standing on Westminster Bridge, close by the Houses of Parliament, and looking across the river to the left, one may see the chimney of a destructor in which is burned the refuse of a portion of the city of Westminster.

Westminster has a population of about 185,000, on an area of four square miles. Its population ranges in character from the royal occupants of Buckingham Palace to some of the poorest tenement dwellers in all London. The destructor is located in a manufacturing and dock district. Mr. W. J. Bradley,* M. Inst. C. E., is city engineer of Westminster, and Mr. Arthur Ventries,† Engineer of the Highway Department, controls the cleansing department, under which the destructor comes. Mr. G. Holt is foreman of the destructor.

The refuse destructor includes six cells, in three pairs back to back, erected in 1900 by the Horsfall Destructor Co., of Leeds. The cells are top-fed, through a special direct charging lid, and have a combined grate area of 252 sq. ft. The chimney is of brick, 92 ft. high. Steam jet blowers are used to produce a forced draft. A Babcock & Wilcox boiler, with a heating surface of 1,426 sq. ft., is placed behind the cells. The boiler supplies steam to drive a mortar mill and also a dynamo for lighting the works. Storage batteries were being installed at the time of my visit, and the lighting system was to be extended to include the stables, office, and the foreman's cottage.

The refuse is collected by the city in four-

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*City Hall, Westminster, S. W.
†Vestry Hall, Piccadilly, Westminster, S. W.

wheeled tipping wagons, with boxes of wood. All the refuse is weighed at the entrance to the destructor. The vans hold some 2 cu. yds. each, and I was told at the weighing office that an average load would weigh 2,800 lbs. The rated capacity of the destructor is 72 tons in 24 hours, and it was said that an average of about 70 tons a day is burned.

The dumping floor is at a comparatively slight elevation above Commercial St., and is paved with wood blocks. The inclined approach has a stone pavement.

The wagons are tipped directly into the cells, one pair of which can receive two loads at a charge. The refuse is subsequently pulled forward from the lower or stoking and clinkering floor. Each charging hole is provided with a counterbalanced lid, lifted by a wheel and endless chain. The lid is seated in a water seal, to retain smoke and gases, and a special cover is let down to exclude dirt from this seal when the cells are being charged.

The hot clinkers are dropped into skips, running on an overhead trolley from the clinker doors to a lift, or elevator. At the top of the lift the skips are conveyed by a second trolley to a mortar mill, or else they are sent some 300 ft. in another direction and tipped into a barge.

The mortar mill has been added since the destructor was built. It consists of a revolving iron pan, about 8 ft. in diameter and 15 ins. deep, in which are two heavy rolls working on a horizontal shaft. At the time of my visit all clinker not used by the city for filling or otherwise was being sold, but formerly some of it had been barged away at the expense of the city. The fine ashes below the grates were also being sold. There is no sale for the flue dust. It was formerly mixed with carbolic acid for use as a disinfectant. I was informed that Mr. Bradley put a stop to what at best seems

a doubtful practice, but is still followed at Battersea. All tins pass through the destructor and go away with the waste clinker.

The works are operated in both 8- and 12-hour shifts. There are three stokers on each 8-hour shift who are paid 35 shillings, or $8.50, a week, and two top men on each 12-hour shift who are paid 28 shillings, or $6.80, a week. One of the two night topmen acts as a "carman"; that is, he uses a horse to bring stored wagon loads of refuse into position for tipping. In addition to the force named there is a single night and day foreman, whose wages I did not learn, and two weigh clerks, whose wages are not charged to the destructor.

I visited this plant about 5 p. m. on Friday, March 25, 1904. No odor whatever was noticed, and there was but little smoke, and that light, coming from the chimney. Smoke and dust were pouring out around one of the charging lids, but I was told that the lid was temporarily out of order.

There was but little green stuff in the refuse, and I was informed that in winter the refuse is usually very light in weight, containing large amounts of paper and ashes, while in summer the green stuff runs up to half the total amount collected. Some collections are now made at night. The cells are run some three months at a time without being shut down, unless special repairs are required.

A test of the whole six cells was made by Mr. Bradley on Dec. 2 to 4, 1902. During the 45½ hours of the test 310,828 lbs. of refuse were burned, which was at a rate of 27,476 lbs. per cell per 24 hours, or 27.2 lbs. per sq. ft. of grate surface. The average temperature observed in the main flue was reported as "over 2,000° F.," and the average temperature behind the boilers as 500° F. With 9 stokers at 35 shillings, or $8.50 a week, and 4 topmen at 27½ shillings, or $6.68 a week, the labor cost was at the rate of 11½ d., or

23 cts. per long ton of refuse burned. The clinker and ash was 24.9% of the original weight of the refuse.

THE REFUSE DESTRUCTOR AND THE UTILIZATION OF CLINKER AT BATTERSEA, LONDON.

The refuse destructor of the London borough of Battersea is one of the older British destructors. It is of the Fryer top-fed type, and was erected in 1888, by Manlove, Alliott & Co., of Nottingham, a number of years before there was any attempt to combine destructors with electric generating stations. There is a boiler, however, in which steam is raised for works purposes. Perhaps the most interesting feature of this plant is the utilization of the clinker residue for various purposes, including the manufacture of artificial flagstones in a hydraulic press.

Battersea has a population of 168,907, and an area of 3¼ sq. miles. It is one of the densely populated London boroughs and is notable for its low death rate, its government by working men, and for being the home of John Burns.*

Mr. T. W. A. Hayward is borough surveyor of Battersea, and Mr. Allen Vickers is and for some ten years has been manager of the refuse destructor.

Contract work has long been under the ban in Battersea, and it is rarely employed for refuse collection anywhere in Great Britain. At Battersea, however, the borough not only collects the refuse, but it also manufactures the vans or four-wheeled wagons used for the purpose. These wagons are of wood, are provided with two springs parallel to the rear wheels, and are dumped by means of a screw lift. The sides are so high that a ladder is provided with each wagon for loading, and to lessen the danger of accident

*See "John Burns and the Battersea Metropolitan Borough," Engineering News, April 28, 1904.

the upper ends of the ladders are fitted with hooks and the wagons with side rails. The wagons cost £40, or about $195 each, and are said to be good for 20 years' service. An empty wagon weighs a long ton, and has a capacity of nearly 2½ cu. yds. The weight of such a load, obviously, varies with the character of the material, but is placed at about 2,240 lbs.

The collections of refuse, six days in the week, range from 100 to 140 loads a day. About half of the refuse is hauled to the destructor and the remainder is delivered to a contractor who takes it some miles down the Thames, where it is used for burning brick. This portion of the refuse is dumped on barges by the borough. The contractor shapes the barge loads and the borough measures them and pays the contractor 10 d., or about 20 cts. per cu. yd., for his work. The barges carry from 45 to 80 wagon loads.

In winter there is only a small amount of green stuff in the refuse, and that is gathered chiefly from costermongers on Mondays. I visited the destructor on Thursday, March 17, 1904. The refuse then contained scarcely a bit of green stuff, or garbage proper. I was told that there is more garbage now than formerly, on account of the increased use of gas stoves.

Each load of refuse is weighed as it enters the works, after which it is dumped on the top of the destructors. Here the large cans, only (or "tins," as they are called in England), are picked out, all others going into the fires.

There are twelve destructor cells. Natural draft, only, is used. The chimney is of brick, 180 ft. high. A multitubular boiler supplies steam for operating the clinker crusher and the flag-making machine.

The capacity of the twelve cells is 60 long tons a day, but this is for two eight-hour shifts.

The clinkers are removed once in two hours. The hottest are quenched with water and bar-

rowed out into a paved yard to cool. The largest pieces are broken by hand, after which the clinker is loaded into a barrow and wheeled up an incline to a steam-driven crusher. This consists of two chilled iron toothed rollers. The clinker is crushed to a maximum size of about 3 ins., dropped into barrows, wheeled to a pile and roughly hand-sorted into three sizes. It is expected that an elevator and a revolving screen will soon be added. The coarsest clinker is used for making concrete and as the medium for the body of sidewalk flags; and the finest either goes to a mortar mill or is used in laying sidewalks.

Before the hydraulic press was secured a considerable quantity of clinker was molded by hand into window sills, lintels, keystones and the like, for use in the cottages built by the borough for housing the working classes. The press was put in operation late in 1903, and I was told that thus far it had given satisfaction. It was supplied and erected by C. & A. Musker, of Liverpool, at a cost of £1,500, or about $7,300, including hydraulic pumps and shafting, but not including an old engine supplied by the borough.

The slabs or flags are 2 ft. wide and 2⅛ ins. thick, and are made in lengths of 2, 2½ and 3 ft., to allow for breaking joints in laying.* The body of the slabs is composed of 4 parts of medium-sized clinker to 1 part of Portland cement, and the upper ⅛-in., or wearing surface, of 3 parts of granite screenings to 1 part of Portland cement.

The slab molds, of which there are three, rest horizontally on a table which revolves on a vertical shaft: while one mold is being filled, the contents of another are being pressed and a third is being emptied. The material which is to form the wearing surface is placed at the bottom of the mold and rests on a perforated plate, made of an

*I observed small flagstones in many places in England, and I also observed that the small sizes were handy on account of the ease with which the flags could be removed for laying wire ducts beneath the sidewalks.

aluminum alloy. Above the plate is a piece of brown paper, which serves as a filter paper. The perforated plate gives the top of the flags an irregular appearance which is more pleasing to the eye than a smooth surface. The hydraulic power pumps maintain a pressure of 2,000 lbs. per sq. in. on the slabs for about a minute. Four men can make 20 slabs an hour, regardless of length. The slabs are stacked on edge in the yard for some three months to dry in the open air.

The ashes that fall through the destructor grates, I was told, sell readily at the works for 6 d., or 12 cts., per long ton. They are used for building purposes.

The flue dust is sifted and carbolic acid is added to it to make a disinfectant for borough work. Some of the powder is placed in refuse receptacles, when the latter are wet, and some is given away in pound packages to anyone who calls for it.

The cans, or tins, are flattened, baled and carted away at a cost to the borough of 1½ shillings, or 37 cts., per long ton, as compared with 2½ shillings, or 62 cts., formerly paid. The man who does this sells the tins to an antimony works. The borough has recently had an offer of 22 shillings, or $5.31, per long ton for the tins, delivered to the London Electron Works, Regent Docks, Horseferry Road, Limehouse, London, but the cost of transportation would have left only a very small profit to the city. It used to be considered worth while to recover solder from old tins, but with the marked increase in the use of molded tinware the amount of solder recoverable has diminished to such an extent as to make its recovery commercially impracticable.

To operate the destructor, six men, including a foreman, are employed on each of the two shifts. The ten men are paid 34 shillings and the two foremen 36 shillings per week of six days, which is the union rate, and is equal to $8.19 and $8.75 per

week, respectively. The labor cost of burning the refuse is given as 48.6 cts. per long ton. Assuming 2½ cu. yds. per long ton, this is practically the same as the cost of having the refuse barged away. The relative cost of hauling the refuse to the destructor and to the barges I did not ascertain, but I did learn that the manager of the destructor is quite willing to send as much refuse as possible down the river.

I observed no indications of nuisance of any sort in or about the destructor. The chimney top was free from smoke.

Refuse Destructors Combined with Night-Soil Works, Sewage Works and Sewage Pumping Stations.

Besides the combinations noted immediately above, there are in England several instances of destructors raising steam to pump municipal water supplies.

THE DISPOSAL OF NIGHT-SOIL AND REFUSE AT BIRMINGHAM.

The cleansing department of Birmingham collects and disposes of the ashes, waste paper, garbage, and similar wastes of the city, and is also responsible for the collection and disposal of excreta from such pan closets as have not yet been converted into water closets. The number of pan closets has diminished from 37,000 to 25,000, and is being lessened at the rate of 50 a week. There are five wharves for the reception and treatment of night-soil and for refuse destructor stations, one at least of the latter being combined with poudrette works. At three of the wharves refuse is passed through revolving screens and the fine stuff is mixed with excreta and barged away as crude manure. The poudrette works will soon be abandoned, after which the diminishing quantity of night-soil will all be mixed with ashes, as just described. Some idea of the operations of the cleansing department may be gained from the

statement that during 1902 the destructors treated 121,000 long tons of refuse, while 29,000 tons were sent to the tips or dumps, 61,438 tons of mixed night-soil and ashes were barged or carted away, and 731 long tons of this and like matter were tipped. The amount of night-soil made into poudrette is not reported.* Mr. William Holt is superintendent of the cleansing department.

Birmingham has a population of about 520,000 and an area of 12,639 acres. Refuse destructors were first put in use in 1877. In 1879 two large destructors were built. In 1899 a fourth plant (described below) was built, and at the time of my visit, in April, 1904, another plant was under construction and still another was projected. The plants built in 1879 were designed by the department. The projected plant will be built by Heenan & Froude, of Manchester. The other destructors are all of the Fryer type, and were built by Manlove, Alliott & Co., of Nottingham.

The projected plant will be located at the sewage works, and the steam from it will be used to generate electricity for light and power for use at those works. This will be known as the Saltley destructor. There will be eight cells, in two units of four each, top-fed from storage bins by means of hydraulic rams. There will be three boilers. One will be a coal-fired stand-by, for use on holidays and in case of emergency. Heenan & Froude destructors are also under consideration as substitutes for the old Montague St. plant, of local design.

My inspection covered only two of the destructors, which will now be briefly described.

THE MONTAGUE ST. DESTRUCTOR.—There are 32 cells here, each with a grate area of about 25 sq. ft. Refuse is stored on the top of the destructors and fed into their tops, but as this

*These figures are from "The Municipal Year Book" for 1904 (London).

does not afford sufficient storage room, some refuse is dumped below and fed into the fronts of the cells. The rough clinker is used for road-making and sewage filter beds, and some is made into slabs for sidewalks by means of a hydraulic press. The tins are now flattened by passing them through corrugated rollers, made into bales of 224 lbs. each, and sold at the works for about 30 shillings, or $7.30, per long ton. The solder is melted out and sold separately. The city supplies the necessary apparatus for handling the tins and gives the workmen who handle them all the solder and about half the amount received for the tins.

There are 14 multitubular boilers at these works, all supplied with heat from the destructors. The steam is used for drying night-soil and for other works purposes. The destructors are operated night and day and burn about 1,000 long tons a week. There was much dirt and dust about this plant, some of which might have been due to the changes in progress.

THE MONTGOMERY ST. DESTRUCTOR.—The twelve Fryer cells here were erected in 1899, are placed back to back and are top-fed by means of Boulnois & Brodie's charging apparatus. The chimney is 195 ft. high above the ground. Forced draft is provided by means of two 6½ or 7-ft. Sturtevant blowers, one to each six cells. Two 8 × 28-ft. Lancashire boilers supply steam to drive the fans and light the works and stables. They could do more work if required.

The refuse is brought into the building over a stone paved ramp and is dumped from a stone-paved tipping floor. The clinkering floor is covered with concrete. The building has brick walls and a slate roof. There is a dust deposit chamber about half way between the cells and the chimney. The charging hoppers or trucks hold two wagon loads, or about three long tons each, and there are two trucks to each cell, with a track

leading to and beyond the feed hole. The extra truck is for storage. When the trucks are brought over a feed hole the cover of the latter is removed, the bottom of the truck opened and the refuse dropped into the cell.

The stoking and clinkering doors are tight-fitted on a counterbalanced horizontal shaft-hinge. The doors are of double plate iron, with an air space between.

The clinkers are delivered to contractors at one shilling, or 25 cts., per 1½ long tons for hauls of one mile or less, and 6 d., or 12 cts., for each half mile additional. The fine ash from below the grates is sold for various purposes and at the same rates. Some of the flue dust is sold to farmers at the cost of haulage, and some is tipped. Tins, scrap iron, bottles and the like are picked out and sold.

The plant is run 144 hours a week and burns an average of 480 long tons in that time. By doubling the number of stokers, I was told, 740 long tons could be burned in a week of six days. I was informed that coal has never been used to assist combustion.

There are one charger or top man and two stokers to each eight-hour shift. The three chargers receive 24 shillings each, or $5.83 a week, and the six stokers 28 shillings, or $6.80 a week. This makes a total of £12, or $58.30 per week. On the basis of 480 long tons per week, the labor cost, as reckoned at the plant, would be about 6 d., or 12 cts., per ton. It will be noted that the labor cost does not include either the engineman or the foreman, but labor costs at most, if not all destructors in England appear to be figured in the same way. That is, they include chargers and stokers only. In this particular case the foreman has charge of the refuse collection for the whole district tributary to the destructor, and all his wages are charged to collection.

I visited the works on April 12. The refuse

which I saw was mostly ashes. I was told that scarcely any green stuff comes to the wharf, and that even in summer it is only some 5% of the total collections. No odors were noticed. The chimney was giving out a little light smoke. Mr. James Thomas Law is foreman of the destructor and of the collection district.

DESTRUCTORS COMBINED WITH SANITARY MANURE WORKS AT ROCHDALE.

Some of the refuse of Rochdale is screened and the more combustible screenings are utilized to supply heat for the sanitary manure works, or plant employed to convert night-soil into a marketable fertilizer. Since 1894 such of the refuse as is not screened has been burned in a refuse destructor and the heat has been utilized for works purposes. This destructor was among the earlier to produce high pressure steam, and by example did much to introduce power production from refuse on a large scale and for other than destructor works purposes.

Rochdale now has a population of about 84,000. Mr. S. S. Platt, M. Inst. C. E., has been borough surveyor since 1881, and for many years Mr. F. W. Brookman has been manager of the sanitary manure works and, later, of the refuse destructor. Mr. J. H. Heywood is assistant to Mr. Brookman, and in the absence of both the other gentlemen named, Mr. Heywood showed me about the combined works on April 14, 1904.

The night-soil or sanitary manure works date from 1869. As now operated, the night-soil is evaporated by means of revolving cylinders, followed by drying plates. The heat for drying is generated in five Cornish boilers, placed end to end and connected with the revolving cylinders. From the cylinders the partly dried night-soil, about the consistency of thick mud, is removed to drying plates, beneath which are passed the partly

spent gases from the cylinders. The gases are then sent through a spray washer and through a condenser and to a furnace. The draft through the cylinders and in the chimneys is increased by means of a Root's exhauster.

The refuse destructor is described as of local design, fitted with Meldrum's steam jet blowers and grates. There are two large cells, fed from the front, with grates 9 ft. long and 5 ft. deep, having the space beneath each grate divided into two ashpits. This permits keeping one side of the fire at a high temperature while the other side or end is being charged or clinkered. A large combustion chamber back of the grate serves as a mixing chamber for the gases from both sides of the grate, and thus aids in maintaining a high temperature and complete combustion. Some will recognize these features as identical with the main features of the Meldrum furnace. The Meldrum people claim this as the first of their destructors. Just how the credit for the destructor should be divided between Mr. Brookman and Meldrum Bros., I will not attempt to say. It may be added, however, that Meldrum Bros. were successful boiler manufacturers before they took up refuse destructors, and that the production of boilers is still a large part of their business.

There are two 8 × 30-ft. Lancashire boilers between the destructor cells and the chimney. The latter, which is 250 ft. high, also serves the five Cornish boilers connected with the night-soil dryers.

About 40 long tons of refuse are burned in the cells each day. The clinker has been used for making mortar and also for contact beds at the Rochdale sewage works.

The combination of night-soil works and refuse screening with shovelling the refuse into the furnaces makes this plant dusty and generally disagreeable, but no offensive odors were noted.

The wages paid at the joint works early in 1904 were as follows: Enginemen, 7¼ d., or 14½ cts., per hour; firemen, 6½ and 6 d., or 13 and 12 cts.; riddle or screen men and general laborers, 4½ d., or 9 cts., per hour.

Three tests of the destructor were made in 1895, which are notable because of the high results obtained. A test on March 1 lasted six hours, and tests on Nov. 14 and Nov. 15 lasted 6½ hours each. Some of the results shown, in order of dates already given, were as follows: Total refuse destroyed, 11.4, 13.75 and 14.3 long tons; refuse burned per sq. ft. of grate surface per hour, 47.3, 52.6 and 54.9 lbs.; water evaporated to 1 lb. of refuse (actual and from and at 212° F.) 1.64 and 1.97, 1.39 and 1.68, 1.47 and 1.78; number of boilers used, 2, 1 and 1; temperature of feed water, 53° F., 52 and 52° F.; average steam pressure per sq. in., 113, 113 and 114.* For the test made on March 1, the following additional figures are available: Clinker, 36% of total refuse burned; temperature of combustion chamber (back of grates), 1,988° F., and after clinkering and fresh charging, 1,290° F. Percentage of CO_2 in products of combustion, 15.9; do. of CO, 0; do., free oxygen, 2.2.

THE REFUSE DESTRUCTOR AT THE ALDERSHOT SEWAGE WORKS.

This is a Meldrum front-fed simplex destructor with four grates, having a grate area of 70 sq. ft. It was built in 1900, and the heat from it generates steam to operate sewage pumps which lift an average daily dry weather flow of 600,000 U. S. gallons a distance of 20 ft. Mr. John Edwards, the manager of the combined sewage works and refuse destructor, told me that it is rarely necessary to supplement the refuse with coal.

*These test figures are from Goodrich's "Refuse Disposal and Power Production" (London, 1904).

The chimney is 70 ft. high. Steam jet blowers are used for forced draft. An average of about 11 long tons of refuse is burned each day. There are two $4\frac{1}{4} \times 14$-ft. Cornish boilers, which have been coal-fired for some twenty years before the refuse destructor was built.

The refuse at the time of my visit was mostly ashes and paper and contained scarcely any vegetable stuff. In summer, I was told, nearly all the refuse is green stuff, but this was the only refuse destructor I saw in Great Britain where so much of what in America is called garbage was reported. I was told, however, that there are many gas stoves in the town. But little smoke was visible at the chimney top.

The clinker from the destructor has been used recently to construct sewage filter beds. It has also been used for road bottoming and for foot paths across fields that are so common and often so pleasant a feature in England.

The destructor is operated whenever the pumps are being run, but the relatively large receiving reservoir renders it feasible to shut down the pumps for about eight hours at night. The force employed at the destructor is three stokers and two enginemen, all at 26 shillings, or $6.32 a week. Two men work Sundays without extra pay, and one man is off duty each Sunday; but as one man leaves early each day they are on the works only 56 hours each per week.

THE REFUSE DESTRUCTOR AT THE SALISBURY SEWAGE WORKS.

The refuse destructor at Salisbury is one of a number in England which are supplying heat to raise steam for pumping sewage. Salisbury has a population of about 17,000. When it finally decided to install a refuse destructor, Mr. A. C. Bothams, Assoc. M. Inst. C. E., City Surveyor, drew up a schedule of desired guarantees and

asked for bids for a plant which would fill the conditions indicated. The result was the acceptance of bids for a Horsfall destructor, which was put in operation the latter part of 1901.

'There are two cells, side by side, fed from the back, and having about 30 sq. ft. of grate area each. The grates, and the drying hearths behind them, are inclined towards the stoking doors. The latter slide up with the aid of a counterweight.

Forced draft is provided by means of steam jet blowers. There is a circular dust arrester. The chimney is of brick and is 120 ft. high above the ground level. The base of the stack and also the flue nearly to the top is surrounded by an air space.

There are two 80-HP. Babcock & Wilcox boilers, with provision for independent firing. I saw no coal, and was told by Mr. Bothams that none is used except in very wet weather (like the summer of 1903) when the volume of sewage continues high and the quantity of refuse available is relatively small. The boilers have a combined heating surface of 1,800 sq. ft. and carry a pressure of 100 to 110 lbs. A Green's economizer with a heating surface of 720 sq. ft. is used for the boiler feed.

On the 23 hours' contract test of the destructors the following result, as compared with the guarantees, were obtained: Twenty tons of refuse were burned in 19 instead of 23 hours; 39.2 lbs. of refuse per sq. ft. of grate surface were burned instead of 32; 1.23 lbs. of water per lb. of coal were evaporated in place of 1 lb.; the maximum furnace temperature was 2,000° F. and the minimum was 1,320° F., instead of 1,800° and 1,200°, respectively, and the average was 1,645° instead of 1,500°. The flue temperature at the inlet to the first boiler was guaranteed to be about 1,600° F., and at the second about 1,400°; the maximum in each case was below the guarantee and the averages were 1,313° and 965°, respectively. The

temperature of the feed water on leaving the economizer was guaranteed to average 250°, but only 214° was obtained. These results were overlooked since all the other guarantees had been exceeded.

About 120 tons of refuse are collected each week, arranged so as to distribute it well through the week and leave some extra for keeping up the fires and for pumping on Sunday. The average daily quantity of sewage pumped is given as 3,600,000 U. S. gallons and the lift is 15 ft.

The labor at the refuse destructor, pumping station and sewage works is interchanged, but is estimated to cost about $6,000 a year, including repairs. Three engineers at 32 shillings, or $7.78, each per week, and three stokers at 24 shillings, or 5.83, per week, are employed, all on eight-hour shifts, and there is one stop-gap man, who serves as either engineer or stoker and who makes needed repairs. Laborers are paid 19 to 24 shillings, or $4.62 to $5.83, a week for a working day of 11 to 12 hours. The manager for the combined works lives in a cottage on the spot, and thus is always on call. He is paid £2¼, or $10.93 a week. Mr. John Hamlin is manager of the works, and has been in the employ of the city for about twenty-five years.

In common with the many other British refuse destructors which I have visited, this one is substantial in construction. The inclined roadway is a solid earth embankment, instead of the wooden trestle and floor so common in America, and the building is of brick, instead of a mere shell of corrugated iron.

THE UTILIZATION OF DESTRUCTOR HEAT FOR PUMPING SEWAGE AT WATFORD.

It is customary in England to have a formal opening of important public works, and it was my good fortune to attend one of these at Watford. This particular opening was to celebrate

the completion of a refuse destructor, the heat from which is being utilized to pump the sewage of the town to a sewage farm.

Watford is a London suburb of some 30,000 inhabitants. Mr. Edward Kingham is chairman of the urban district council, and a lunch was given in his name in honor of the destructor opening. Mr. D. Waterhouse is district surveyor.

The destructor is of the front-fed type, and were erected by Meldrum Bros., of Manchester. There are four grates with one common cell above, but separate ashpits below. This cell is 6 ft. 2 ins. × 22 ft. over all, in plan, and the total grate area is 100 sq. ft. The grates have a slight inclination towards the front and the grate bars are of iron. The separate ashpits permit feeding and clinkering each grate without checking the whole fire by a rush of cold air. The rated capacity of the destructor is 40 long tons in 24 hours. The gases of combustion pass to and are mixed in a combustion chamber, back of and parallel to the cells, and then pass on to the boiler.

The 8 × 30-ft. Lancashire boiler supplies steam for the steam jet blowers used to produce forced draft and also to the sewage pumping station, some 90 ft. distant. The average daily amount of sewage pumped was given as 1,250,000 Imp. or 1,500,000 U. S. gallons. At the time of my visit the pumps (two Worthington triple expansion) were working under a total head of 58 ft. and the boiler pressure was 117 lbs.

Beyond the boiler there is a regenerator which utilizes some of the heat to raise to some 300° F. the temperature of the air supplied for forced draft, and beyond the regenerator there is a Green's economizer for heating the boiler feed water. The air supply for the regenerator is drawn from the building, thus aiding ventilation. The feed water entering the economizer has already been raised to a temperature of about 150° F., it is said, by means of a Boby "heater de-

FIG. 1. REFUSE DESTRUCTOR AND SEWAGE PUMPING STATION, WATFORD, ENGLAND.

tartarizer" or feed water heater, supplied with exhaust steam from the pumping engines.

The chimney is 170½ ft. high above the level of the ground, and has a flue 9 ft. in diameter at the base and 5¾ ft. at the top. The chimney was built by the Custodis Chimney Co.

The destructor is housed by a stone building with an iron roof, the latter slated outside and ceiled with wood inside. The feeding and clinkering floor is paved partly with stone and partly with concrete. The earth ramp or inclined roadway is paved with stone. The main building is about 34 × 79 ft., inside the walls, besides which there is a low addition, covered with corrugated iron, to house the economizer and other accessories.

The refuse is dumped from the ramp into a storage bin, formed by building a wall across the end of the building 6 ft. from the outer wall, and 11½ ft. from the feed doors of the cells. An opening some 2 ft. high at the bottom of the wall permits the refuse to fall onto the feeding floor.

No provision for utilizing the clinker had been made at the time of the opening, but it was expected that it could be used for road and mortar making or sold to sewage works for making filter beds.*

The refuse which I saw was practically all ashes and paper.

The same delays in securing sanitary improvements seem to be experienced the world over. Mr. Waterhouse recommended a destructor in 1893, but it was not put under construction until 1903. Meanwhile a huge pile of refuse accumu-

*On June 18, 1904, Mr. W. F. Goodrich, Assoc. Inst. M. E., wrote to me that the clinker was selling freely at 2 s. 8 d., or about 65 cts. per long ton, and that a two-year contract had been made for the sale of the tins, etc., from the refuse at the rate of 14 s. 9 d., or $3.58, per long ton. The prices in each case are for the material loaded into trucks or cars on the railway siding at the destructor. It appears that the clinker, at the date named, was being sold for use in sewage filter beds.

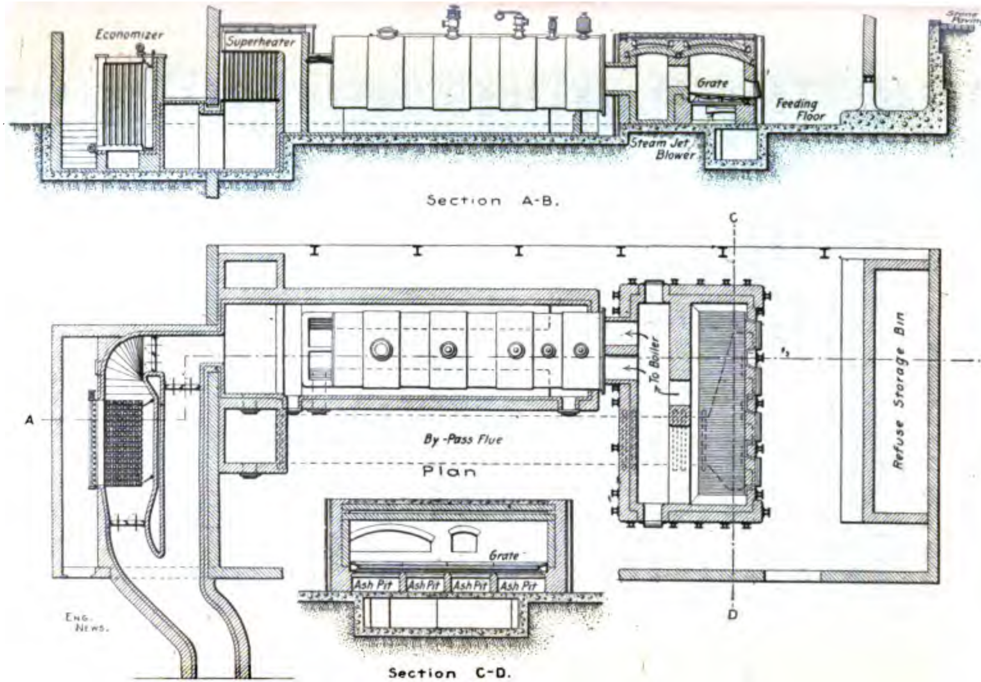

FIG. 2. PLAN AND SECTIONS OF THE REFUSE DESTRUCTOR, WATFORD, ENGLAND.

lated near the site afterwards adopted for the destructor. In 1900 an outbreak of diphtheria in houses near the refuse heap was seized upon by the medical officer of health as an argument for building a destructor. A plague of flies and rats, bred at the dump, was a far more reasonable, if not more convincing, argument.

The destructor was located close by the combined sewage pumping and electricity works, but was provided with a separate chimney. The quantity of refuse being collected at the close of March, 1904, was about 23 long tons a day, and as some 40 long tons are needed to raise sufficient steam to pump the sewage, the old refuse heap was to be drawn upon to make good the deficiency.

The cost of the destructor and accessories, chimney and building, was about £6,800, or $33,066, divided as follows: Destructor, boiler and accessories, £3,495, or $16,985; economizer, £300, or $1,458; building, £1,218, or $5,919; chimney, £1,283, or $6,235; tipping platform, £503, or $2,469. These figures include nothing for land, which was already owned by the town.

The average annual cost of pumping the sewage with coal for fuel during the three years befor installing the refuse destructor was given at the time of the destructor opening as follows: Coal, £890, or $4,325; firemen, £125, or $608; total, £1,015, or $4,933. The cost of refuse disposal at the tip was £52, or $253, per year for wages and disinfectants, which added to the cost of pumping made £1,067, or $5,186, for maintaining the refuse tip and pumping the sewage before the destructor was established.

The annual cost of operating the destructor, it was expected at the time of the opening, would be: Interest and sinking fund, £460, or $2,235; labor in handling refuse (estimated), £410, or $1,993; repairs (estimated), £100, or $486; total, £970, or $4,714. This shows an apparent saving

FIG. 3. FRONT VIEW OF REFUSE DESTRUCTORS, WATFORD, ENGLAND, SHOWING FEED AND ASH PIT DOORS.

[illegible] of 29?, or $472, with no allowance [illegible] revenue from clinker or, on the [illegible] no debit allowance for its dis-[illegible] there was no demand or only a par-[illegible] it.

[illegible] was guaranteed to burn 40 long [illegible] in 24 hours, and to evaporate 1 lb. [illegible] of refuse. On a nine-hour test* [illegible] guarantees were exceeded by [illegible] 30%. The refuse delivered [illegible] 33,517 lbs., including 1,295 [illegible] and the like, or 2.33% of the [illegible] burned in the nine hours was [illegible] lbs. per sq. ft. of grate sur-[illegible] was clinkered five time during [illegible] 7.63 minutes each time. The [illegible] of the refuse burned.

[illegible] evaporation, with the aid of the econ-[illegible] the rate of 1.29 lbs. to 1 lb. of [illegible] and at 212° F. the evaporation [illegible] 1.56 lbs. The feed water en-[illegible] at 53° F. and left it at an [illegible] and a maximum of 322° F.; but [illegible] by-pass damper was open half [illegible] the test, since the station regu-[illegible] a feed water temperature of [illegible] at the economizer outlet.

[illegible] temperature in the combustion [illegible] the destructor, which is back of the [illegible] as 2,700° F. and the "average [illegible] temperature" as 2,000°. The tem-[illegible] gases in the boiler downtake was [illegible] minimum; 1,106° average. [illegible] the temperatures were 455°, [illegible] maximum, minimum and average. [illegible] pressure was 1.1 ins. and the [illegible] The pulls at the chimney [illegible] 1 and 1.03 ins., maximum, mini-[illegible]

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* [illegible] have been taken from the "Pub-[illegible] (London) for Aug. 27, 1904.

Installations Old and New, Including the Largest Destructor Plant in the World.

The remaining notes illustrate the varied character of the destructors visited. As previously explained, most of the plants were visited at random, thus including some of the poorest as well as the best examples.

REFUSE DESTRUCTOR AND ELECTRICITY WORKS AT ACCRINGTON.

Accrington has a population of about 43,000 and an area of 3,426 acres. Mr. W. J. Newton, Assoc. M. Inst. C. E., is surveyor, and Mr. H. Gray, M. Inst. E. E., is electrical engineer to the borough.

Six top-fed Horsfall cells, placed in a row, were installed in 1900. They have a total grate area of 180 sq. ft. and a rated daily capacity of 60 long tons. The amount of refuse actually burned, I was told, is from 50 to 60 long tons a day. Back of the cells are 7½ × 30-ft. Lancashire boilers, with a heating surface of about 1,000 sq. ft. each. As these supply steam to an electric light and power plant, supplementary coal-fired grates were placed between the cells and the boilers for emergency use. The electric plant is also provided with an 8 × 28-ft. coal-fired boiler. All the boilers are equipped with Green's economizers. Steam jet blowers are used to produce a forced draft. The chimney of the combined plant is over 240 ft. in height and is of brick. Between the economizers and the chimney is a dust-catcher, which utilizes centrifugal action to deposit the dust in chambers.

The destructor building is of brick. The tipping floor has a stone pavement supported on iron girders. The clinkering floor is of concrete.

The clinkers are raked into small wheeled trucks, run out on a track and dumped into a pit, from which they are fed into a crusher. An elevator takes the crushed clinker to a screen which rejects the dust and all pieces above 2 ins.

by the change of £97, or $472, with no allowance for the possible revenue from clinker or, on the other hand, with no debit allowance for its disposal in case there was no demand or only a partial demand for it.

The destructor was guaranteed to burn 40 long tons of refuse in 24 hours, and to evaporate 1 lb. of water to 1 lb. of refuse. On a nine-hour test* both these guarantees were exceeded by somewhat over 50%. The refuse delivered amounted to 55,517 lbs., including 1,295 lbs. of tins, pots and the like, or 2.33% of the total. The amount burned in the nine hours was 54,222 lbs., or 60.32 lbs. per sq. ft. of grate surface. Each grate was clinkered five time during the test, requiring 7.63 minutes each time. The clinker was 25.84% of the refuse burned.

The actual evaporation, with the aid of the economizer, was at the rate of 1.29 lbs. to 1 lb. of refuse, while from and at 212° F. the evaporation was at the rate of 1.56 lbs. The feed water entered the economizer at 53° F. and left it at an average of 243.2° and a maximum of 322° F.; but the economizer by-pass damper was open half way throughout the test, since the station regulations do not allow a feed water temperature of more than 300° F. at the economizer outlet.

The maximum temperature in the combustion chamber of the destructor, which is back of the grates, was reported as 2,700° F. and the "average approximate temperature" as 2,000°. The temperature of the gases in the boiler downtake was 1,500° maximum; 800° minimum; 1,106° average. At the chimney base the temperatures were 455°, 300° and 409°, maximum, minimum and average. The average ashpit pressure was 1.1 ins. and the maximum was 3 ins. The pulls at the chimney base were 1.12, 1 and 1.03 ins., maximum, minimum and average.

*The results of the test have been taken from the "Public Health Engineer" (London) for Aug. 27, 1904.

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The destructor building is of brick. The tipping floor has a stone pavement supported on iron girders. The clinkering floor is of concrete.

The clinkers are raked into small wheeled trucks, run out on a track and dumped into a pit, from which they are fed into a crusher. An elevator takes the crushed clinker to a screen which rejects the dust and all pieces above 2 ins.

in size. The clinker is then used for concrete street foundations. Some has been used for filter beds at the local sewage works and a little has been sold to another municipal sewage works.

For the three months prior to my visit the destructor had been run night and day. Previous to that it had been shut down between midnight and 6 a. m. On the 24-hour basis the works are operated in three shifts, with one top man, one stoker and one wheeler-out to each shift. These men are paid from 6½ to 5 d., or 13 to 10 cts., per hour.

The refuse which I saw on April 15, 1904, consisted almost wholly of ashes and contained no green stuff whatever.

The electric equipment includes five engines with a total of 970 HP. and five dynamos with a combined capacity of 580 KW. Chloride batteries of 750 ampere hours' capacity are also provided.* There were only 300 electric consumers at the time of my visit. The output last year was about 280,000 Board of Trade Units.

Mr. Gray estimates that a fifth of the steam consumption is supplied by the destructor boilers. It has been found from tests that a unit on the consumer's meters costs about 0.4 d., or 0.8 ct., when obtained from coal, and on figuring the yearly averages of cost anything under that figure is credited to the destructor. Last year 0.2 d. was so credited (which does not seem to agree with the foregoing statement that the destructor furnished one-fifth of the power required, unless there has been a large recent increase in the load).

Mr. Gray himself thinks, and believes all electrical engineers agree, that it is not best to combine refuse destructors and electricity works. He

*The figures in this sentence and the results of tests, given below, are from Goodrich's "Refuse Destructors for Power Production" (London, 1904).

much prefers coal for fuel, on account of the excessive labor cost for handling refuse.

The actual quantity of refuse burned in November, 1901, was 2,132,256 lbs. The destructor was shut down Sundays, so the average quantity burned per day was about 82,000 lbs., or about 36.5 long tons.

A 22-hour official test of the destructor and one boiler was made on April 11 and 12, 1901. A total of 117,846 lbs. of unscreened mixed refuse was burned. This was equivalent to 21,424 lbs. per cell per 24 hours, or 29.7 lbs. per sq. ft. of grate surface per hour. A total of 135,624 lbs. of water was evaporated, which was at the rate of 1.15 lbs. of water per lb. of refuse at actual temperature and 1.39 lbs. calculated from and at 212° F. The mean steam pressure was 185 lbs. The mean temperatures were as follows: Main flue, 2,000° F.; behind the boiler, 500° F.; feed water, 50° F. The clinkers and ashes amounted to 35.5% of the weight of the refuse burned. Mr. Goodrich (see foot note) gives the labor cost at this plant as about 33 cts. per long ton and the electric output at 25 Board of Trade Units per long ton of refuse burned.

The total cost of the destructor, buildings and chimney, exclusive of site, was about £8,000, or a little less than $40,000.

YORK.

I had time for only a hasty glance at one of the two destructors at York and found that new electric works are receiving all steam not needed for operating the destructor accessories.

York has a population of about 78,000 and an area of 3,692 acres. Mr. Alfred Creer, Assoc. M. Inst. C. E., is city engineer.

The plant which I saw consists of four Fryer's top-fed cells, erected in 1898, equipped with Boulnois & Brodie's charging trucks. A fan is used

to provide forced draft. The buildings were of the solid construction common to destructors in Great Britain.

The clinker is crushed and variously used, some going to a mortar mill at the works. Tins have recently advanced in price from 3½ to 5 shillings, or from 85 cts. to $1.22 per long ton.

AN OLD DESTRUCTOR AT BOURNEMOUTH.

Among the older destructors in England and one of the few that still rely upon natural draft, is the one at Bournemouth. This popular seaside health and pleasure resort has a population of about 60,000, distributed over an area of 5,850 acres. Mr. F. W. Lacey, M. Inst. C. E., is borough surveyor of Bournemouth.

The destructor now includes six top-fed cells, of which four were built by Manlove, Alliott & Fryer in 1887 and two by Goddard, Massey & Warner in 1891. The differences between the two installations are chiefly in minor details. The chimney is of brick and has a height of 137 ft.

Coal has never been used to aid combustion, and although the destructor, like all of an early date, is of the low temperature type, provision was made at the outset for utilizing some of the otherwise waste heat. To that end the heat was used in preparing material for tar concrete sidewalks. The plant was given up on account of the long haul for both the raw and prepared material. At present the heat is by-passed, when desired, beneath iron plates on which sand is spread to dry for use on rails of the municipal tramway system, a branch of which passes near by.

A Jones fume cremator was in use for about three years, but it was expensive in operation, and as there were no complaints against the destructor when the cremator was not used, it was shut down.

As is the case at nearly every refuse destructor which I saw abroad, the ramp or inclined roadway

here is of earth. The tipping space is paved with stone.

All the refuse is collected by the borough. The collecting equipment includes two large steam dust vans, or motor wagons, made by the Thorneycroft Steam Wagon Co., of Basingstroke. The vans hold four or five ordinary wagon loads. They are provided with steel boxes and each has a screw, work by a crank, for dumping.

The refuse brought to the works is not weighed. It is estimated to aggregate 40 long tons a day, which appears to be about half the total amount collected by the borough. The balance is tipped.

A recent proposal to provide a second destructor was thwarted, owing to the fact that adjacent property-owners, who had a veto power, objected to the site chosen. The present site is near the center of one side of the borough and distant from annexed territory on either hand. There are a number of small houses within 400 to 500 ft.

Some of the clinker is used for road bottoming, but none is sold. The tins are dumped in deep fills in new roads and compressed by a steam road roller.

The destructor is run night and day, except that the fires are banked and the dampers closed from Sunday morning to early on Monday morning. Six men are employed, including the foreman, in two shifts of three each. The men are paid 29 shillings, or $7.05, a week, and the foreman receives 30 shillings, or $7,30, a week. This makes a payroll of $42.55 a week, or about 17 cts. per long ton for 240 tons of refuse per week.

I visited the destructor on April 7, 1904. In the several loads of refuse which I saw there was scarcely any green stuff, and the foreman said that most of such as did come was from markets. A slight odor was noticed when I first came alongside the cells; evidently from the charging floor. The chimney gave out but little smoke.

The foreman at the destructor has worked there ever since it was opened, and has been in the employ of the municipality for 37 years.

REFUSE DISPOSAL AT GLASGOW.

Glasgow has five destructor installations with an aggregate of 59 cells, but not all of its refuse is burned. The bulk of what we should call garbage is shipped by rail to one of several farms owned by the city.

The population of Glasgow is about 780,000, and its area is 12,688 acres. Mr. A. B. M'Donald is city engineer and surveyor, and Mr. D. McColl is superintendent of the cleansing department.

Three of the older destructors, with a total of 30 cells, were designed by the department. Of these two have chimneys 250 ft., and one has a chimney 300 ft. high. A plant of five Horsfall top-fed cells, erected in 1898, has a chimney 250 ft. high, steam jet blowers, and a Babcock & Wilcox boiler which supplies steam for the blowers and for works purposes.

THE DALMARNOCK DESTRUCTOR.—This plant is located at the Dalmarnock sewage works. It was erected in 1901 and in 1903, and includes 16 grates, provided with steam jet-blowers for forced drafts. The chimney is 250 ft. high. The cells are of the Meldrum top-fed type. Three Lancashire boilers supply steam for the blowers, for lighting the works and for breaking and screening clinkers. The surplus heat is delivered to the sewage works.

The clinker is sold for use in making concrete. The solder is recovered from the tins, and the scrap iron, bottles and the like are sold.

THE MARY HILL OR RUCHILL DESTRUCTOR.—The eight Fryer's top-fed cells of this plant were installed in 1902 by Manlove, Alliott & Co., of Nottingham. Two 8 x 30-ft. Lancashire boilers supply steam to drive fans for

forced draft, a clinker crusher and screen and a dynamo to light the works. The chimney is 200 ft. high. Golfers on hilly ground near by complain of the chimney, but, I was told, without cause.

The rated capacity of the destructor is 80 long tons a day, and from 60 to 70 tons are now brought to it. Everything that comes is burned, unless it has a marketable value. I saw hundreds of old shoes that had been put aside for sale.

The destructor is operated in two eleven-hour shifts of five men each, not including the crusher men. One shift extends from 6 a. m. to 5 p. m., and the other from 6 p. m. to 5 a. m.

I visited this destructor on April 18, 1904. Nearly all the refuse which I saw was ashes. No odor was noticed and the chimney was giving out but little smoke.

BRADFORD.

Bradford has four destructors with an aggregate of 38 cells. Each plant has a chimney 180 ft. high and uses steam jet blowers to produce forced draft. At three of the destructors the steam raised is used for works purposes, only, but from one of them steam is delivered to electricity works.

The population of Bradford is about 280,000 on an area of 22,843 acres. Mr. Ernest Coll is cleansing superintendent. I made hurried visits to two of the destructors on April 21 in company with Mr. John Watson, Managing Director of the Horsfall Destructor Co., of Leeds.

THE SUNBRIDGE ROAD DESTRUCTOR.—Nine old cells of another make have recently been rebuilt and three cells added, all of the Horsfall top-fed type, with storage at the rear. Each cell has a grate of 30 sq. ft. area. The charging holes are stopped by the refuse, instead of by lids, and the refuse is pushed onto the fires through

these holes, instead of being hauled forward or pushed in from the rear through doors reached from the lower floor. A hood is placed above the clinkering doors and from this warmed air is drawn to be forced through the grates at the rear of the cells and down into the ashpits.

The cells are placed in a single row and behind them are two Babcock & Wilcox marine type boilers, rated at 200 HP. each. The rated capacity of the destructor is ten long tons per cell per day or 120 tons in all, and the contract guarantee for rebuilding called for a yearly electrical output of 1,000,000 Board of Trade units. There is a Green's economizer and electric storage batteries will be added.

The destructor building and the chimney are of brick, and the ramp, tipping and clinkering floors and clinker yard are paved with stone. A dust catcher, based on centrifugal action, is provided.

The clinker is raked into buckets working on overhead trolleys, one to each cell. There are two mortar mills for utilizing the clinker and a dynamo for lighting the works.*

When I visited the destructor scarcely any green stuff was visible in the refuse, and but little smoke was seen at the chimney top.

The standard wage for laborers at all the Bradford destructors, Mr. Watson said, is five shillings, or $1.22, per eight-hour shift, during which each man handles an average of seven long tons of refuse; that is, one charger handles 14 tons and one stoker clinkers the same amount.

SOUTHFIELD LANE DESTRUCTOR.—There are six cells here, similiar to those just described. There is also one 8 x 30-ft. Lancashire

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*In the "Public Health Engineer" (London) for August 20, 1904, it was stated that a rental of £120, or $583, a year was derived from power supplied from this destructor to run a weaving shed; also that the municipal corporation has decided to fully utilize the heat from this destructor by supplying steam to a new electric station, not far distant, for lighting and street car purposes.

boiler, two clinker crushers, an elevator, a rotary screen and a mortar mill. The crusher is simply two fluted chilled iron or steel rolls.

The ramp is stone-paved, with iron wheel tracks. There are a mess-room and a bath-room for the workmen.

TESTS OF THE HAMMERTON ST. DESTRUCTOR.*—The first destructor at Bradford was erected at Hammerton St. in 1880 and 1882. About 1890 forced draft was added, and in 1897 the twelve cells were rebuilt by the Horsfall Company. The plant is equipped with two 8 x 11-ft. multitubular boilers which supply steam for jet blowers, a flag- or slab-making plant and other works purposes.

A test extending over 278 hours was made June 24 to July 7, 1900, during which 2,896,320 lbs., or 1,293 long tons of mixed refuse were burned. This was at the rate of 9.3 long tons per cell per 24 hours or 34 lbs. per sq. ft. of grate surface. A total of 2,153,000 lbs. of water was evaporated, or 0.743 lbs. actual and 0.882 lbs. from and at 212° F. per lb. of refuse. The temperatures were as follows: Gases in main flue, 1,800° F.; gases at chimney base, 1,000° F.; feet water, 60° F. For each ton of refuse burned there were 83.2 I.H.P. The residuals amounted to 379.65 long tons, or 29.36% of the original refuse, divided as follows: Clinker, 364.96 tons; fine ash, 12.02 tons; fine dust, 2.67 long tons.

The average weights per cubic foot of different classes of refuse consumed during the test were as follows: Ashpit, 42.2 lbs.; market, 22.6 lbs.; light refuse, 19.2 lbs.

The labor charges during the test were: 6 chargers at 25 shillings or $6.05 a week and 12 stokers at 28 shillings or $6.80 a week, making an average of 9 d., or about 18 cts., per long ton.

*Prepared from figures given in Goodrich's "Refuse Destructors and Power Production" (London, 1904).

THE LARGEST REFUSE DESTRUCTOR IN THE WORLD: HAMBURG, GERMANY.

The lagest refuse destructor in the world, if I mistake not, is located at Hamburg, Germany. Other cities have a greater aggregate of cells, but not under one roof. The Hamburg destructor, however, serves only a portion of the city. The refuse from other sections is used for agricultural purposes or is tipped, as was all the refuse of the city before the destructor was installed. I am indebted to Mr. Rud. Schroder, Chief Inspector of the pumping and filtration division of the Hamburg water-works, for taking me to the destructor, introducing me to Mr. Otto Uhde, Chief Engineer and Manager of the plant, and serving as an interpreter.

The destructor was built in 1895 and put in operation in January, 1896. Until January, 1901, it consumed the refuse from a population of about 300,000, and since that time the tributary district has been increased to include a population of 420,000, or perhaps a half of the whole city.

The plant comprises 36 top-fed Horsfall cells, in units of six cells, placed back to back. Originally the forced draft was provided by means of steam jets, but soon after the plant was accepted the city substituted fan blowers. The contract guarantee was for 5 long tons of refuse per cell, but on changing the nature of the forced draft this quantity was exceeded and now from 7 to 10 long tons per cell are burned. Doubtless other factors, such as extra labor per unit for stoking, have contributed to the increase. The chimney is of brick, approximately 8 ft. in internal diameter at the base and 160 ft. high.

I saw monthly diagrams showing the operations of the destructor for years. Less refuse per cell is burned in winter than in summer. Last summer the maximum rate was 10 long tons per cell, as compared with 8 and even 7 tons in winter.

Mr. Uhde stated that this difference was due to the fact that the greater proportion of waste coal in the winter refuse seemed to result in a coking process. The summer temperatures in the destructor are also higher than those obtained in the winter. Among the many refuse destructors and garbage furnaces which I have visited in Europe and America this is the only one at which I ever saw a pyrometer.

No coal is used to assist combustion. The coal used throughout the city, I was told, gives a residue more favorable to refuse destructors than that burned in Berlin, where brown coal is used and the cinders have little fuel value. This statement is of interest in view of the alleged failure of some experimental destructor cells tested at Berlin a few years ago. The refuse which I saw at Hamburg on May 13, 1904, was largely composed of ashes, with some paper and old tins, but scarcely any green stuff.

Refuse is collected at night in wagons having removable boxes of 4 cu. m. or 5.2 cu. yd. capacity. There are four reversed hooks on each box, to which four chains, hanging from an electric overhead traveling crane, are attached. The boxes are then lifted, moved laterally, and tipped onto a storage platform adjacent to the charging holes. There is one feed hole to each pair of cells. The tins are not picked out of the refuse.

The cells, or most of them, are equipped with hand-worked movable grate bars. The sides of each cell, for about 8 ins. above the grates, are cooled by means of water.

Four multitubular boilers are provided for raising steam from the gases of combustion. Each boiler has a heating surface of 200 sq. meters or 2,152 sq. ft., and in case of emergency each can be fired with coal. Engines of 260 HP., effective, drive a dynamo which furnishes the power required at the plant and supplies current for storage batteries on a steam launch and for operating

four 40-E. HP. sewage pumps at a station four miles distant. Another electric pumping station is proposed. The electric launch is used to collect refuse and night-soil from all the boats that come into the harbor. The night-soil is emptied into the sewers and the refuse is brought to the destructor and burned.

Clinkers are removed at intervals of 1½ hours, and are said to equal 50% of the original refuse. The clinkers are raked into small cars, run into a tower in the yard and quenched by means of water jets. An attempt to remove the iron from the clinker by means of a magnet proved unsuccessful and the iron is now picked out by hand. The clinker is crushed, after which it is screened to three sizes. Some of the larger material is used for pavement foundations, for concrete, for filter beds at sewage works elsewhere and for sidewalk slabs or flags. The fine stuff is used to fill in beneath floors. The dust from the screen is exhausted through a pipe to a chamber where it is deposited by means of falling water.

Except on two holidays the plant, from year end to year end, is never completely shut down. Some cells are closed on Sundays, but enough are kept going to supply power to the sewage pumping station.

The men work in eight-hour shifts and for each shift there is one charger to each six cells and one stoker to each three cells, making 6 chargers per shift or 18 per 24 hours, and 12 stokers per shift or 36 per 24 hours. The chargers are paid 3.9 marks, or 97.5 cts., and the stokers 4.1 marks, or $1.025, per shift. This is approximately $1 a day for 44 men. Assuming an average of 8 long tons per cell per day gives a total of 288 long tons burned at a cost of $44, or 15 cts., per long ton for charging and stoking.

I was told that a cell equipped for experimental purposes with a Root blower and fixed grate bars,

and stoked every ½ instead of 1½ hours, had burned as high as 27 long tons a day.

A mess-room and shower baths are provided for the workmen, and once in about two weeks the workmen's clothes are sent to the municipal disinfecting station.

The chimney is of brick, about 8 ft. in diameter at the base and 160 ft. high. At the time of my visit it was giving out only a light, vapory smoke.

THE NEW REFUSE DESTRUCTOR AT ZURICH, SWITZERLAND.

One of the most recent destructor installations in Europe and one of the comparatively few on the Continent was opened at Zurich early in 1904. Through the kindness of Professor Carl Hilgard, M. Am. Soc. C. E., of the Zurich Polytechnic School, I was introduced to Herr Gluek, the head of the health department of Zurich, and to Herr Mettler, the inspector of public health. The four named visited the destructor on May 7, and as nearly all the fires were out, we improved the opportunity to inspect the main flue, which is here placed between the double row of cells.

Zurich has a population of about 160,000. Owing to the high cost of coal, the chief fuels used are wood and gas. Most of the garbage is collected by farmers and others and fed to hogs. As a result of these local conditions, the refuse at Zurich is quite unlike that found in Great Britain. The total amount collected by the city is now about 500 tons a week, all of which, including tin cans, is passed through the destructor. Some street sweepings are included in the above total.

The twelve cells are of the Horsfall top-fed type and have a grate area of 30 sq. ft. Forced draft is supplied by a fan with a capacity of 7½ cu. ft. per sec., driven by a 15-HP. electric motor. The chimney is of brick, 6½ ft. in diameter at the base and nearly 200 ft. high.

Two Babcock & Wilcox boilers, with a provision for independent coal-firing, supply steam to a 220-HP. steam turbine. The later drives a dynamo which operates a traveling crane and the fan already mentioned, besides supplying current to light the destructor. Any surplus heat, I was told, will be delivered to the municipal electric light and power plant. The boilers are fed with condensation water.

The refuse wagons arrive at the destructor on the ground level and as old wagons were still in use, the whole of each wagon, instead of the box only, was hoisted by the overhead traveling crane and emptied as best it can be on top of the destructors.

The clinkers are raked into small wheeled trucks and run outside on rails.

The destructor is operated continuously from 5 a. m. Monday to 10 p. m. Saturday. Chargers and stokers alike are paid only 4½ francs, or 90 cts., for an eight-hour day. Their wage should be increased, I was told, to 6 francs a day, since the cost of living in Zurich is high. This is particularly true of rents, three rooms and a kitchen costing 450 to 500 francs a year.

A handsome five-story brick apartment house has been erected by the city, close by the destructor. It contains seven sets of family apartments, besides rooms for single men and an office. It will be heated by steam from the destructor. The apartments and single rooms will be rented to the men employed at the destructor.